ENDURO

THE PERFECTED STAINLESS ALLOY

ENDURO STAINLESS ALLOYS

ENDURO S—Chromium 13%, carbon under .12%. Suitable for applications where moderate corrosion resistance combined with high strength and toughness are required. Oxidation resistance to 1500° F.

ENDURO FC—Similar to "S," but with free machining qualities added.

ENDURO AA—Chromium 17%, carbon under .10%. For applications where corrosion resistance is more important than high strength or toughness. Good bending and forming qualities. Oxidation resistance to 1600° F.

ENDURO KA2—Chromium 18%, nickel 8%, carbon under .16%. Excellent general corrosion resistance to atmosphere, salt air, food and dairy products, nitric acid, etc. High ductility and best drawing qualities. Oxidation resistance to 1600° F.

ENDURO KA2S—Similar to "KA2," but with carbon under .07%. For applications requiring high physical properties above 1000° F. and for welded fabrication where subsequent heat treatment is not possible.

ENDURO KA2B—Similar to "KA2," but with added silicon. Oxidation resistance to 1700° F.

ENDURO KA2Mo—Similar to "KA2" but with 3% molybdenum added.

ENDURO HC—Chromium 28%, carbon under .20%. Designed for oxidation resistance to 2100° F., where great strength and toughness are not required. High resistance to sulphur and sulphur gases, hot or cold.

ENDURO HCN—Chromium 23%, nickel 12%, carbon under .20%. Oxidation resistance to 2100° F., with physical properties higher than "KA2S."

ENDURO KNC-3—Chromium 25%, nickel 21%, carbon under .25%. For applications requiring highest strength and oxidation resistance at highest temperatures.

ENDURO KA2, KA2S, KA2B, KA2Mo, HCN and KNC-3 are produced under Krupp-Nirosta patents.

The ENDURO STAINLESS ALLOYS . . .

MOST present or prospective users of stainless alloys have at some time been conscious of a lack of accurate basic information which would permit them to select intelligently and to fabricate successfully the particular type of stainless best suited to a given requirement. Obviously, no single type can meet all conditions of corrosion and temperature. A series of booklets has therefore been prepared to supply this exact information on the Enduro Stainless Irons.

Stainless Iron generally is an alloy of iron and chromium, or of iron, chromium and nickel, with very low carbon content. The stainless properties of the alloy are due to the ability of chromium to form with iron a solid solution which is resistant to the various corrosive media. It is essential that sufficient chromium be present in solid solution to ensure stainless properties. The chromium contents of Enduro Stainless Irons have been adjusted accordingly.

Stainless irons as a class do not respond to hardening by heat treatment. Neither do they require special heat treatment other than that received at the mill to develop stainless properties. Stainless irons as a class lend themselves to deep drawing and other forming operations.

There is a distinction between stainless iron and stainless steel, though the latter term is popularly if erroneously used to designate all stainless alloys. Strictly speaking, stainless steel is an alloy of iron, chromium and carbon. The amount of carbon is such that the material hardens upon quenching. This branch of the stainless family is suitable for cutlery and applications where high physical properties, hardness and wear resistance are required, but does not lend itself to deep drawing or forming.

Not only does stainless steel require very careful polishing, but it must also be carefully heat treated before polishing to develop its corrosion-resisting properties.

Types of Enduro Stainless — To meet the demands of industry for corrosion-resisting alloys suitable for a wide variety of specific purposes, the Enduro Stainless Irons have been developed in a number of types. In this development all factors affecting corrosion resistance have been considered and their relative importance established. The result is a series of alloys possessing maximum corrosion resistance and physical properties, consistent with ease of workability, for each field of application. It is noteworthy that this has been accomplished without unduly increasing the cost of the alloys.

Selection of Type and Finish — Enduro Stainless Irons are furnished in several different finishes. The finish of the stock used will depend on the amount of forming necessary. It is inadvisable to use polished sheets for extra deep drawing operations where score marks from dies are likely to occur in forming or where it is necessary to reanneal to make a second drawing operation. An unpolished, fully annealed and pickled sheet designated as our number one (1) finish should be used. Polished finish should be used only where stock will be employed without further working or where the degree of working is small.

Corrosion Resistance — Much harm has been done by exaggerated claims of corrosion resistance. Metals and alloys are resistant to corrosion in different degree, none being entirely proof against all corrosive agents. Each metal or alloy is limited

as to the field in which it is serviceably resistant; hence while it may possess excellent resistance in its field, it by no means follows that it will be equally resistant to all attacking media under all conditions.

To simplify this problem we group the application of the Enduro Stainless Irons under three headings:

1. Atmospheric Corrosion — understood to mean exposure to weather conditions.
2. Wet Corrosion — understood to mean partial or total immersion in corrosive liquids.
3. Dry Corrosion — understood to mean scaling at elevated temperatures.

Atmospheric Corrosion — In this field the Enduro Stainless Irons are excelled by no other stainless alloys. The higher the alloy content of each Enduro type, the more resistant the alloy is to corrosion by weather exposure. In addition to this result from higher content of alloys, the forming and deep drawing qualities also are favorably influenced, particularly by the addition of nickel. All types of Enduro Stainless Irons produced by Republic Steel Corporation are suitable for general resistance to atmospheric corrosion.

Wet Corrosion — Enduro Stainless Irons are resistant to nitric acid and similar oxidizing agents, to sulphur and sulphur compounds and to the more common organic acids occurring in the household. They are not resistant to hydrochloric or sulphuric acids except under special conditions.

The rate at which corrosion (solution of the alloy in the corrosive liquid) takes place depends upon a number of factors, among which are the concentration of the other elements in the solution and the character of the solvent; the temperature; the state of the solution, whether agitated or at rest; the amount of dissolved oxygen or other oxidizing agents present; the presence of impurities in the solution which might act as inhibitors, or themselves attack; electrolytic action because of contact with other metals, etc.

Since these and other factors affect the rate at which corrosion takes place, it is questionable whether laboratory tests on the stainless irons are of great practical value except insofar as they indicate whether attack does or does not take place and if it does, whether rapidly or slowly. Tests on samples of Enduro Stainless Irons under actual conditions are much preferable to calculations of probable corrosion rate based on laboratory data. The Republic Steel Corporation has a large amount of corrosion data obtained from tests in pure solutions and also from actual application of the various alloys under service conditions. If the prospective user of Enduro Stainless will submit the application to our metallurgical department a recommendation will be made.

Dry Corrosion — Enduro Stainless Irons are resistant to scaling at elevated temperatures. Each type is best suited for certain conditions and temperatures. All Enduro Stainless Irons are resistant to sulphur gases up to 1000°F.

In dealing with the application of Enduro Stainless Irons to high temperature service it is important to differentiate between intermittent and continuous service. This is necessary because some of the stainless alloys have a tendency to cast off their protective scale when alternately heated and cooled, due to difference in the coefficient of expansion between the scale and the metal itself. There has been established a maximum temperature for these service conditions which is given for each type of Enduro.

Physical Properties at High Temperatures

IN selecting a material for the design of equipment which is to be used under high temperature conditions, where high stresses may be encountered, as in oil refinery operations, the following qualifications are necessary:

(a) The metal must have the requisite strength at the specified temperature.

(b) It must not oxidize under the action of the flame or hot gases.

(c) It must not become brittle while in service.

(d) It must resist the corrosive action of the materials with which it is in contact, such as liquids, gases, etc

Enduro on the Chrysler Tower

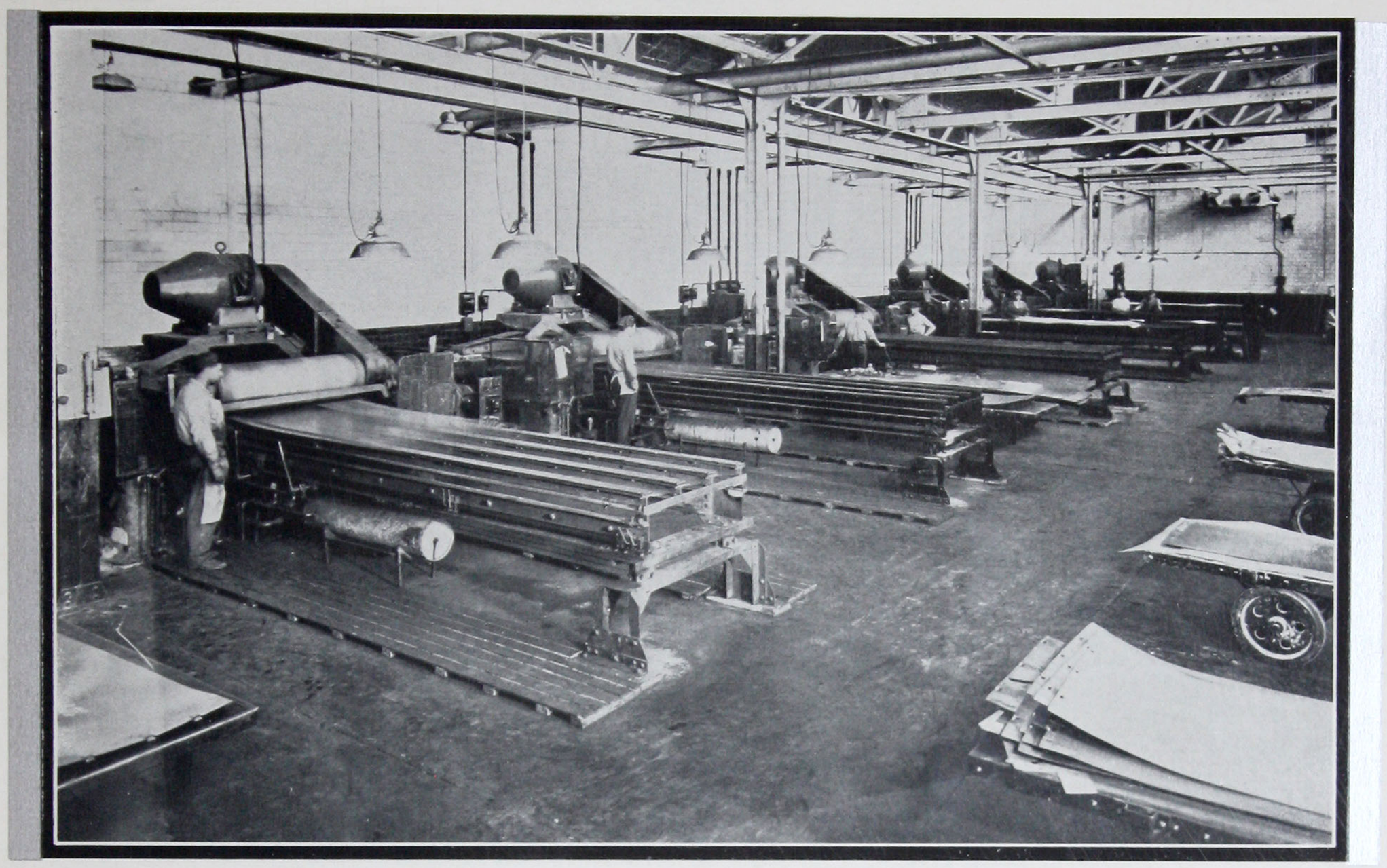
The tensile strength of metals, as ordinarily determined at room temperatures, does not vary greatly with the rate at which the load is applied. But when the test is made at high temperatures the rate of pulling of the tensile test piece has a marked effect on the ultimate tensile strength obtained. The more slowly the test piece is pulled, the lower is the strength shown by it. It is thus apparent that the tensile strengths of metals at high temperatures as ordinarily determined by short-time tests cannot be used for design purposes. It is equally evident that the effect of stress on the metal held at a high temperature for a long time must be known before it is possible intelligently to design equipment to be used under such conditions.

If the strength of a metal at a given high temperature is determined only by ordinary tensile tests, a piece of equipment subjected to that temperature for a longer time, under pressure, using a safe fiber stress as determined by the short-time tests, will progressively stretch, or "creep." This will continue until a point is reached where the metal thickness becomes so greatly reduced that the pressure can no longer be withstood, and the apparatus will fail.

It is well to note that this reduction in the thickness of the metal may also be hastened by the effects of corrosion, or of oxidation, or a combination of both.

In order to design apparatus or equipment suitable for service at various elevated temperatures, when stresses will be high, it is necessary to determine the "creep strength" of the metal. The "creep strength" at a given temperature may therefore be defined as the stress at which the metal will elongate 1% during 100,000 or 10,000 hours at that temperature.

The "creep strength" of each Enduro type, as compared to plain carbon steel is given in comparison under each type. In applying this data to problems of practical design, stresses should be used corresponding to the highest temperatures anticipated, or a factor of safety introduced to prevent safe stresses being exceeded, should the temperature accidentally be increased.



A Few of the Polishing Machines in Republic's Finishing Division

Preparation of Surface • Polishing

THE preparation of the surface to be exposed to corrosive attack is of the utmost importance. When the highest degree of corrosion resistance is desired, the scale resulting from hot working must be removed and the surface ground and polished.

To secure the permanent, beautiful, silver-white lustre characteristic of Enduro Stainless Irons, which permits them to replace such materials as nickel plate, chromium plate, nickel silver, tinned copper, and the copper nickel alloys, it is necessary that certain precautions be observed. Polishing and buffing equipment which has been used for polishing other metals should have all such metal particles carefully removed before use in polishing Enduro. Careful selection of polishing grits and buffing compounds is necessary to insure their freedom from iron, as otherwise such iron may be worked into or remain on the surface of the polished article and will under corrosive conditions give the erroneous impression that the stainless alloy is rusting.

A factor of equal importance is that all surface imperfections must be removed to secure maximum corrosion resistance. In polishing flat surfaces it is necessary to begin operations with coarser grits than when polishing formed articles. The rule should be to use the finest abrasive possible and

yet remove all of the surface imperfections, the reason being that coarse grit marks are very difficult to remove.

A polishing speed of from 5000 to 7000 lineal feet per minute is productive of very good results. The first few polishing operations may be done dry, but the final operation should be done on greased wheels. Care must be exercised not to burn the work, the lower coefficient of thermal conductivity making this danger greater than when polishing copper, brass or steel.

The buffing of Enduro Stainless Irons must be done with iron-free buffing compound. This precludes the use of ordinary jeweler's rouge. Green chrome oxide is a suitable material where a mirror finish is not necessary; however, when such a finish is necessary special buffing compounds are required followed by the use of chromium oxide to bring out the color. The speed of buffing should be higher than that of polishing, 7200 to 12000 lineal feet per minute.

As regards polishing, the character of the finish of the exposed surface is the most important factor in producing resistance to stain and tarnishing; hence, the more perfect the finish, the less the likelihood that the metal will stain.

When formed articles do not require maximum resistance to corrosion and are to be used in the "as drawn" or semi-polished condition, it is recommended that the article be given a passivation or cleansing treatment.

When using stainless iron in the semi-polished condition there will usually be some discoloration of the exposed surface. This eventually develops into a permanent, tightly adherent surface coating which, if appearance is not a primary consideration, does not adversely affect the life of the metal.

Passivation of Enduro Stainless Alloys— Polished sheets as furnished for exposure to weather conditions are given a special surface treatment before shipment from Republic Steel Corporation. This treatment is known as a "Passivation Treatment" and insures proper resistance to corrosion, staining, and discoloration.

In installing such polished sheets on buildings the fabricator will often find it necessary to cut, machine, punch, shear, bend, or otherwise work the metal with the result that the passivated condition is destroyed. In forming the sheet the forming tools usually are made of regular die steel. There is a possible abrading action between the stainless metal and the steel die which may leave a surface film of iron on the stainless surface after the forming operation. This film should be removed by the passivating treatment as otherwise a form of rusting will appear after the unit is placed in service. With certain forming operations it is possible to use paper or other lubricating compounds between the stainless metal and the steel die, which will prevent the abrading action.

Where this is not possible it is recommended that after such operations the metal surface be repassivated in the following manner:

1. Wash thoroughly in kerosene to remove all traces of grease, drawing compounds, etc., and dry by rubbing with whiting.

2. Immerse in a 20% by volume solution of commercial nitric acid at a temperature of 130°F. for 20 to 30 minutes. This acid will not attack the metal nor destroy the surface finish. (Tanks for holding such acids should be lined with stainless alloy.)

If impossible to immerse pieces, all sheared edges, drilled or punched holes, engraved or scratched surfaces should be swabbed or scrubbed with the above nitric acid solution.

3. Rinse in clear water to remove all traces of acid, and dry.

Cleaning of Polished Enduro— To keep polished Enduro surfaces clean, use soap and water, with a "grease free" drying and polishing cloth. Where necessary to use a polish, Bon Ami is recommended. Do not use liquid metal cleaners, as they are liable to dull the lustre.

Tile and brick cleaning compounds are likely to contain ingredients which may etch or discolor Enduro Stainless and it is therefore recommended that when Enduro is installed in conjunction with tile or brick it be wiped with a greasy cloth to protect the surface when the tile is cleaned.

Contact with Other Metals— The use of polished Enduro Stainless sheet and trim on the outside of buildings may necessitate the use of steel supports that are welded or otherwise attached to the stainless metal and then attached to the steel structure of the building. These points of contact of steel to stainless should be protected from corrosion as much as possible; a coating of paint is recommended.

The contact of Enduro Stainless with other metals should be avoided where electrolytic corrosion is apt to occur (wet corrosion). Under all other conditions, it is satisfactory to have Enduro Stainless in contact with dissimilar metals.

Applications

Following are a few of the applications in which the various types of Enduro have met with conspicuous success.

Enduro K A 2 —

Bottling machinery.
Canning and preserving equipment.
Cold storage plant apparatus.
Cooking utensils.
Dairy and milk handling machinery.
Dyeing, bleaching and finishing machinery.
Exterior building trim.
Ham boilers.
Household electrical appliances.
Ice cream freezers and cabinets.
Laundry machinery.
Washing machines and parts.
Meat slicing machine parts.
Packing house equipment.
Paper and pulp machinery.
Electric refrigerator parts.
Restaurant equipment.
Salt dryers.
Soap making machinery.
Soda fountains and counters.
Sterilizers.
Street lamps.
Sugar refinery machinery.

Enduro A A —

Abattoir equipment.
Bakery equipment.
Bottling machinery.
Builders' hardware.
Candy making machinery.
Canning or preserving equipment.
Chemical plant apparatus.
Cooking utensils.
Golf club heads.
Ice making machinery.
Nitric acid plant equipment.
Nitrogen fixation apparatus.
Oil refinery equipment.
Pyrometer protection tubes.
Recuperators.
Rubber plant machinery.
Septic tanks.
Scientific apparatus.
Soot blowers.
Tanks—all kinds.
Varnish kettles.
Etc., etc.

Enduro S —

Automobile parts such as pump shafts, etc.
Beater bars for paper mills.
Gage and indicator parts.
Locomotive safety valve seats.
Mining machinery and equipment.
Rifle and revolver barrels.
Pumps or pump parts.
Railroad equipment.
Steam turbine parts.
Shafts for deep well pumps.
Valve parts for high pressure steam, and for oil refinery equipment.
Parts requiring high physical properties.

Enduro is available in bars, castings, forgings, plates, sheets, strip, tubing, wire and innumerable finished products through fabricators.

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